California Environmental Protection Agency

Air Resources Board

TEST PLAN TO DETERMINE THE CALIFORNIA SPARK-IGNITION PLEASURECRAFT HYDROCARBON AND EVAPORATIVE EMISSIONS INVENTORY AND EVALUATE CONTROL TECHNOLOGIES FOR EVAPORATIVE EMISSIONS REDUCTION

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Draft -Test Plan to Determine the California Spark-Ignition Pleasure Craft Hydrocarbon Evaporative Emissions Inventory and Evaluate Control Technologies for Evaporative Emissions Reduction

I. Purpose

The test plan presents a strategy to develop the state's spark-ignition (SI) pleasure craft hydrocarbon evaporative emissions inventory and evaluate the effectiveness of control technologies to reduce emissions in support of the State Implementation Plan (SIP) ozone attainment objectives.

II. Background

In 2002 the U.S. EPA proposed a rule to control the evaporative emissions of spark-ignition (SI) marine vessels and highway motorcycles. This rule for marine vessels was not adopted. The proposed rule was characterized by the marine industry as an excessive burden on small business marine vessel and equipment manufacturers and called for the elimination or modification of many of the proposed controls. Also, the Air Resources Board (ARB) commented that the proposal did not include controls for fuel tank venting, a major evaporative emission contributor.

Recently, the U.S. EPA proposed a new rule to control hydrocarbon evaporative emissions from SI marine vessels (Reference: Control of Emissions from Nonroad Spark-Ignition Engines and Equipment, April 17, 2007). The new proposal will control permeation of fuel tanks and fuel lines using similar standards established for recreational vehicles. Additionally, it will include diurnal venting control using passively purged carbon canisters or by pressurizing the fuel system. ARB will evaluate the pending U.S. EPA proposal to determine if it adequately addresses California's ozone attainment objectives. In addition, we will proceed with our own rulemaking regardless of the degree of harmonization with the U.S. EPA proposal, to secure enforcement authority and ensure future changes to U.S. EPA rulings do not adversely affect California's emissions inventory.

A limited evaporative emissions inventory test program was contracted by ARB from 2001 to 2003. After a re-evaluation of the test program, ARB concluded the test program must be completed to validate the current estimated evaporative emissions inventory. ARB conducted a pleasure craft evaporative emissions workshop April 12, 2006. The National Marine Manufacturers Association (NMMA) and elements of its membership were the primary stakeholders in attendance. At the workshop ARB announced its intent to harmonize with an U.S. EPA proposal if it is deemed responsive to California's needs. NMMA extended support to obtain test exhibits for ARB and requested an opportunity to review our test plan.

III. Test Plan Overview

This test plan has two basic objectives:

1. Verify California's pleasure craft evaporative emissions inventory
2. Evaluate emission reduction control technology supporting SIP objectives

At the conclusion of the inventory and control technology testing, ARB will determine if potential U.S. EPA design engineering control technologies and certification procedures are adequate to achieve California ozone attainment objectives.

ARB has requested and received test data shared by other organizations. The data may be referenced in a final report. Some testing may be performed to validate the test results.

Verify California's pleasure craft evaporative emissions inventory

Automotive Testing Laboratories, Inc. (ATL) tested nine pleasure craft from 2001 to 2003 (Reference: Final Report, Collection of Evaporative Emissions Data from Off-Road Equipment, November 24, 2003). The data was used to determine the California pleasure craft evaporative emissions inventory. The inventory has been questioned because:

- the boat populations used did not agree with Department of Motor Vehicle (DMV) records,
- the test boats may not have been representative of the State's population, and
- no running loss tests were performed.

ARB will address the questions concerning population, representation, and the lack of running loss test data by conducting a thorough review of DMV records, performing boat owner surveys and field usage tests, and conducting running loss tests.

Whole-boat evaporative emission testing inside a sealed housing for evaporative determination (SHED) is preferred for inventory development. Twenty-four in-use boats of different types and ages will be SHED tested. A new ARB test boat will be purchased to help establish baseline emission values. Testing will be accomplished using winter and summer California reformulated phase 2 and 3 fuels with 3 California SHED temperature profiles. Additionally, deterioration tests will be conducted through 600 hours of operation.

Many boats will not fit in the SHED, nor can a water medium to moor the boat be replicated inside the SHED. Alternative testing may be necessary, such as

performing component or subsystem tests to evaluate large boats and developing a water temperature profile to simulate testing boats normally moored at a marina.

This plan's test requirements may be altered because of the following:

- data reviews indicate a need,
- non-availability of equipment,
- limited time, and
- excessive costs.

Evaluate emission reduction control technology supporting SIP objectives

ARB will also determine the effectiveness of new control technologies that reduce evaporative emissions. If the U.S. EPA marine vessel evaporative emission rulemaking is adopted, ARB may harmonize and adopt a similar rule. U.S. EPA proposed design engineering control certification specifications for:

- fuel tank permeation,
- fuel hose permeation, and
- fuel tank vent control with a passive carbon canister or by pressurizing the fuel system

ARB will determine the effectiveness of the U.S. EPA proposed design controls on pleasure craft evaporative emissions and correlate their certification specifications with ARB control technology test results.

Other control technologies such as fuel injection, active fuel system carbon canister control, improved fuel system fittings, better insulation, and refueling may be evaluated.

IV. Test Plan

Evaporative Emissions Inventory Development

The test plan for inventory development addresses requirements identified in David Chou's Planning and Technical Support Division (PTSD) memorandum to Jim Watson, Monitoring and Laboratory Division, titled Evaporative Emission Testing for Pleasure Craft, dated June 19, 2006.

Preliminary temperature study: A preliminary temperature study will investigate ambient temperature effects on a boat fuel tank while the boat is stored and operated. The data may be used to adjust preconditioning and SHED hot soak temperatures. See Appendix A for the Pleasure Craft Preliminary Temperature Monitoring Test.

Inventory development testing: 32 boats distributed over a 2 year period will undergo running loss, hot soak, diurnal, and refueling tests. Testing is to concentrate on newer technology applied to outboards, inboards, personal watercraft (PWC), jetdrives, and sterndrives across a range of horsepower. The

data will be used to establish an emissions inventory as well as a baseline value for pleasure craft control technology evaluation. Appendix B, Table 2, is a matrix identifying the boat type, model years, and tests requested. Noted on the matrix are tests ATL completed earlier.

Most test boats are expected to be loaned to ARB and cannot be modified to conduct SHED tests. Real-world running loss tests may be performed on the water and refueling tests may be performed at a roadside gasoline dispensing facility (GDF) or marina. Vented emissions from both tests would be trapped at the fuel tank vent with a purged carbon canister and weighed. All 32 boats will undergo running loss tests and approximately 25% will undergo refueling tests. ARB will purchase one new outboard test boat for inventory and control technology testing.

Time constraints, SHED access, costs, and redundant tests already performed by ATL may reduce the total number of boats tested. ARB will prioritize testing by starting with late model boats and working back in time. The availability of a particular boat will also influence this schedule.

Ethanol Fuel Testing (Predictive Model Testing**):** An ethanol fuel study will be conducted to determine the effect of ethanol on evaporative emissions. For a complete list of tests and equipment included in the ethanol fuel study see Appendix B.

Temperature profiling, fuel formulation, and deterioration tests: The test plan identifies a series of SHED and refueling tests performed on the purchased ARB outboard test boat that help evaluate the effects of ambient temperature, different State mandated fuel requirements, and equipment deterioration. This is accomplished by testing the same boat with different temperature profiles and various fuels. Deterioration effects are tested through 600 hours of boat operation, but may be amended due to time constraints.

Temperature profiling will be accomplished using summer ozone, winter, and annual diurnal temperature profiles developed by ARB. Summer and winter California reformulated phase 2 and 3 fuels will be tested. CE10 test fuel will also be included in the test series to allow correlation between evaporative emission inventory test data and control technology test data. Deterioration tests will be conducted at the completion of each 150 hours of operation.

Appendix C, Table 3, is a matrix identifying the proposed temperature profile, fuel formulation, and deterioration tests and the type of tests to be performed. Appendix D, Table 4, identifies the temperature profiles.

Surveys and field studies: A survey of California boat owners will be conducted to determine how, when, and where pleasure craft are operated and stored. Additionally, a one-year field study will be performed to determine the frequency and duration of pleasure craft operation. Ten data loggers will record date and time-tagged on/off boat engine operation. The owners will be selected from DMV boat registrations. The first 10 owners meeting geographic and boat description

criteria, that are willing to have their boats monitored and agree to complete a usage log, will be selected (see Appendix E, Pleasure Craft Usage Survey and Field Study).

Evaporative Emissions Control Technology Testing

To determine the efficiency of evaporative emission control technologies, one new carbureted outboard boat will be purchased by ARB to undergo progressive control technology retrofitting and SHED testing. Running loss, hot soak, diurnal, and refueling tests will be conducted. The new boat will be tested before it has been wetted with fuel 30 or more days after its date of manufacture to establish the level of hydrocarbon emissions not contributed by fuel. A 30-day preconditioning follows with California phase 3 reformulated gasoline (CaRFG3) summer fuel. The new boat is then tested as an inventory exhibit. Afterwards, the new boat is preconditioned again for 30 days with CE10 test fuel and tested to establish a control baseline. Subsequent progressive control technology retrofit testing is performed with CE10 test fuel. Appendix F, Table 5, Control Technology Evaporative Emissions Testing, identifies the boat selected for testing, the progressive retrofits, and the type of test to be performed. The control technology will be added in the following order:

1. Low permeation fuel tank
2. Passive carbon canister (fuel tank vent control) with non-vented filler cap
3. Low permeation feed hose
4. Fuel injected outboard engine
5. Low permeation vent and filler hose
6. Low loss fittings and connectors

It should be noted that the fuel injection retrofit will be accomplished by replacing a new stock 2006 carbureted Honda engine with a new stock fuel injected 2007 Honda engine. After the retrofits, a final SHED test will be conducted with CaRFG3 summer fuel, following a 30-day preconditioning period to determine the evaporative emissions effectiveness with commercial gasoline.

U.S. EPA and ARB Correlation Testing

If ARB harmonizes with the U.S. EPA potential rulemaking, a correlation must be established between their design engineering certification test parameters and ARB control technology test results. ARB will diurnally test U.S. EPA control technology components with CaRFG3 summer fuel and CE10 test fuel. The hydrocarbon losses will be measured gravimetrically. This test will be followed with the proposed U.S. EPA test parameters which will most likely include a 24-hour constant temperature test at 23°C for fuel hos es and 28ºC for fuel tanks with CE10 test fuel.

Little is known about U.S. EPA carbon canister testing at this time. ARB correlation tests will be determined following review of the U.S. EPA proposal. Appendix G, Table 6 and 7 identifies correlation tests for marine fuel hose and fuel tanks.

Product Durability

Certified marine hose and fuel tanks are expected to meet durability standards established by CFR 33. The U.S. Coast Guard was contacted to determine if they were proposing durability standards for carbon and carbon canisters. None are expected at this time. The U.S. Coast Guard feels CFR 33 aptly addresses carbon canister requirements within sections addressing the fuel tank and fuel tank venting. ARB will work with industry to determine durability standards for carbon and carbon canisters. If ARB harmonizes with the U.S. EPA marine regulation, ARB would likely adopt U.S. EPA durability standards.

Safety Study

Harmonization with the U.S. EPA regulation would include adopting U.S. EPA fire and safety standards. ARB will coordinate its own regulatory action with the U.S. Coast Guard, the California Department of Boating and Waterways, Department of Consumer Affairs, and the California State Fire Marshal.

Quality Assurance/Quality Control

Testing and calibration will be conducted in compliance with ARB standards and test procedures titled: California Evaporative Emission Standards and Test Procedures for 2001 and Subsequent Model Motor Vehicles, Adopted: August 5, 1999. It adopts provisions of Title 40, Code of Federal Regulations (CFR), Part 86, Subparts A and B as adopted or amended as of July 1, 1989, and Subpart S as adopted or amended on May 4, 1999, with specific exceptions and additions. The engineer or representative conducting the tests will validate quality assurance/quality control data for background, recovery, and retention checks to insure they meet requirements of the California standards and test procedures and 40 CFR Part 86.

SHED temperature data is collected on a minute by minute basis. The engineer or representative conducting the tests will review the data and flag data outside specified parameters. The engineer must then determine if the flagged data should be accepted or rejected.

Test fuels will be analyzed by ARB's Southern Laboratory Branch to ensure they meet ARB and SAE specifications.

Gravimetric equipment will be calibrated annually by certified agents with traceable standards. Traceable standards will also be used before each series of data measurements.

Appendix A

Pleasure Craft Preliminary Temperature Monitoring Test

Table 1

Pleasure Craft	Temperature Monitoring			
	Setting	**Ambient Air**	**Water**	**Fuel Tank Fuel**
SHED Size Boat	72 hour typical use	x	x	x

Purpose: The preliminary temperature monitoring test is performed on a SHED size boat to evaluate how ambient temperatures affect a boat's fuel tank temperature during normal use. This would include land storage, transporting, refueling, and operation on the water. The data will be used to determine the appropriate SHED soak and test temperature settings for running loss and hot soak tests.

Procedure: At least 24 hours before a recreational outing, begin data logging the ambient, water (when placed in water), and fuel tank fuel temperature of a boat stored at a home. Transport, refuel, and operate the boat in a manner typical of a weekend day outing. Include the high temperature reached during the day within the time of the outing. Return the boat to the home and continue temperature recording until the end of the following day.

Test Requirements:

Boat size (SHED size boat): 16-20 feet long
Fuel capacity: Approaching 20 gallons or more.
Tank construction material: Plastic
Data logging: Continuously record ambient and fuel temperature at one-minute intervals for the 72-hour test.
Ambient conditions: Preferably, the day's high temperature must equal or exceed 95F at the home.
Record Keeping: Document the route and road time, time in and out of the water, engine on and off times, and the refueling time and the gallons purchased.
Thermocouple Locations[1]:

1. Ambient Air: Above deck, shaded or shielded, below highest point of the boat, and removed from other thermal influences.

2. Water: 3 inches below the lowest water rippling, 3 inches from the boat, and away from the exhaust heat. Water temperatures when the boat is operating may be taken at spot locations.

3. Fuel Tank Fuel: 1/4 distance from the bottom of the tank to the fuel level.

[1] Other thermocouple locations may be used due to accessibility or unique design. No fabricated or partitioned part of the boat should be altered while monitoring temperature. Hatches should be in their normal position.

Appendix B

Emissions Inventory Testing (32 Tests)

Table 2

	Pleasure Craft Description		Emissions Inventory Tests				Ethanol Testing for Predictive Model		
Test Number	Boat Type	Model Year	Running Loss[1]	Hot Soak	1-Day Diurnal	Refueling[1]	E0	E6	E10
1	Outboard	1980-1989	1	1	1	1	x	x	x
2	Outboard	1990-1999	1	1	1	1	x	x	x
3	Outboard	2000-2003	1	ATL2	ATL2	ATL1	x		
4	Outboard	2000-2003	1	1	1	1	x	x	x
5	Outboard	2004-2007	1	1	1	1	x		
6	Outboard	2004-2007	1	1	1	1	x		
7	Outboard[3]	2004-2007	1	1	1[4]	1	x	x	x
8	Outboard	2004-2007	1	1	1	1	x	x	x
9	Personal Watercraft	1980-1989	1	1	1	1	x	x	x
10	Personal Watercraft	1990-1999	1	ATL2[2]	ATL2[2]	1	x	x	x
11	Personal Watercraft	2000-2003	1	ATL1[2]	ATL1[2]	1	x		
12	Personal Watercraft	2000-2003	1	1	1	1	x	x	x
13	Personal Watercraft	2004-2007	1	1	1	1	x		
14	Personal Watercraft	2004-2007	1	1	1	1	x		
15	Personal Watercraft	2004-2007	1	1	1	1	x		
16	Personal Watercraft	2004-2007	1	1	1	1	x	x	x
17	Sterndrive	1980-1989	1	1	1	1	x	x	x
18	Sterndrive	1990-1999	1	ATL1[2]	ATL1[2]	1	x	x	x
19	Sterndrive	2000-2003	1	1	1	1	x	x	x
20	Sterndrive	2000-2003	1	ATL1	ATL1	ATL1	x	x	x
21	Sterndrive	2000-2003	1	1	1	1	x	x	x
22	Sterndrive	2004-2007	1	1	1	1	x	x	x
23	Sterndrive	2004-2007	1	1	1	1	x	x	x
24	Sterndrive	2004-2007	1	1	1	1	x	x	x
25	Sterndrive	2004-2007	1	1	1	1	x	x	x
26	Inboard Vessels	Not specified	1	1	1	1	x	x	x
27	Inboard Vessels	Not specified	1	1	1	1	x	x	x
28	Inboard Vessels	Not specified	1	1	1	1	x	x	x
29	Inboard Vessels	Not specified	1	1	1	1	x	x	x
30	Inboard w/Jet Drive	Not specified	1	1	1	1	x	x	x
31	Inboard w/Jet Drive	Not specified	1	1	1	1	x	x	x
32	Inboard w/Jet Drive	Not specified	1	1	1	1	x	x	x

ATL# signifies the number of boats that have already been tested by Automotive Testing Laboratories (ATL) under ARB contract 00-315 for a particular model and test. Predictive model testing will include the following fuels: CaRFG3 Winter Fuel (E0), CaRFG3 Summer Fuel (E6), and CE10 (E10).

[1]Running loss will be conducted on all boats and refueling tests may be limited to 6 boats. The tests will be real-world tests rather than conducted in a SHED. Loaned or leased boats cannot be modified for testing.

[2]Identifies a 2-cycle. Two additional 1977 boats were tested by ATL which are not listed above.

[3]The shaded 2004-2007 outboard pleasure craft is a new boat ARB selected for purchase to undergo a series of temperature, fuel, and deterioration profile tests as well as control technology evaporative emissions tests.

[4]Tested during an extended 3-day diurnal test as part of a control technology evaporative emissions test (see Appendix F, Table 5).

Appendix C

ARB Outboard Test Boat Profile Testing (16 Tests)

Table 3

	Temperature Profile Testing			Fuel Formulation Testing					Deterioration Testing					Test Type			
Test Number	Summer Ozone	Emfac Winter	Emfac Annual	CaRFG3 Summer	CaRFG3 Winter	MTBE Summer	MTBE Winter	CE10	0 Hours	150 Hours	300 Hours	450 Hours	600 Hours	Running Loss	Hot Soak	1-Day Diurnal	Refueling
1	x			x					x					x	x	x	x
2	x				x										x	x	
3	x					x									x	x	
4	x						x								x	x	
5	x							x						x	x	x	x
6		x		x											x	x	
7		x			x										x	x	
8		x				x									x	x	
9		x					x								x	x	
10		x						x							x	x	
11			x	x											x	x	
12			x					x							x	x	
13	x									x				x	x	x	
14	x										x			x	x	x	
15	x											x		x	x	x	
16	x												x	x	x	x	

Temperature profile selections contain all profiles prioritized in PTSD July 26, 2006, email titled: "Follow-up to our July 20 Discussion," from Walter Wong. Additional testing not requested in the email, includes an annual temperature profile and testing with CE10 fuel.

The shaded tests are satisfied by the control technology evaporative emissions test numbers 2 and 3. Only the first day of the 3-day diurnal test data is used for the 1-day diurnal requirement (see Appendix F, Table 5).

All fuels are analyzed by ARB.

Appendix D

Different Temperature Profiles

Table 4

Hour	EMFAC Temperature Profile Annual Temp	Summer Temp	Winter Temp	Summer Ozone 65-105 F Temp
0	55.3	62.6	51.5	65
1	54.6	61.9	50.4	66.6
2	54.1	61.1	49.7	72.6
3	53.6	60.6	49.1	80.3
4	53.3	60	48.9	86.1
5	53.2	59.6	48.5	90.6
6	54.3	60.4	48.4	94.6
7	56.8	63.9	49.2	98.1
8	60.4	68.7	52.6	101.2
9	63.8	73.1	57.7	103.4
10	66.5	76.6	62.2	104.9
11	68.6	79.4	65.6	105
12	70	81.4	67.8	104.2
13	70.8	82.8	68.8	101.1
14	71.2	83.5	69.2	95.3
15	70.7	83.3	68.8	88.8
16	68.9	81.9	66.9	84.4
17	66.2	79.3	63.4	80.8
18	63.2	75.5	59.7	77.8
19	60.7	71.5	57.3	75.3
20	59	68.5	55.7	72
21	57.8	66.6	54.4	70
22	56.8	65.1	53.4	68.2
23	56	64.1	52.8	66.5

Appendix E

Pleasure Craft Boat Owner Survey and One-Year Field Study

A pleasure craft boat owner usage survey will be conducted to develop the pleasure craft evaporative emissions inventory. Approximately 1000 boat owners will be selected from DMV records sorted by name, address, boat type, and geographic area to obtain 100 individuals willing to complete the survey. The boat owners will be asked when, where, and how they use and store their boats. 10 respondents will be asked to participate in a one-year field study where boat activity will be monitored with a date and time tagged on/off state data logger.

Usage Survey

PTSD will:

1. Determine the survey target quantities and focus groups
2. Provide MLD a list of boat owners from the DMV database sorted by name, address, type of boat owned, and geographic area
3. Provide a questionnaire that addresses their concerns
4. Provide a format to compile the data

MLD will:

1. Fund the survey
2. Develop the method of conducting the survey
3. Perform the survey
4. Compile the data

Field Study

PTSD will:

1. Identify the type of boats and geographic locations the 10 data loggers will be distributed
2. Define a format to compile the data

MLD will:

1. Purchase the equipment
2. Locate the field study participants from survey respondents
3. Install the equipment and collect the data
4. Compile the data for PTSD

Appendix F

Control Technology Evaporative Emissions Testing (11 Tests)

Table 5

Test Number	ARB Test Boat	Boat Configuration with Stepped Control Modifications							Test Fuel			SHED Tests			
		As Delivered	Control Tank Permeation	Passive Carbon Canister	Fuel Feed Hose	Fuel Injection	Vapor Carrying Hoses	Fittings	No Fuel/Blank	CaRFG3 Summer	CE10 Fuel	Running Loss	Hot Soak	1 or 3-Day Diurnal	Refueling
1	New 2007 Carbureted Outboard[1]	x							x					1	
2	New 2007 Carbureted Outboard[2]	x									x	x	x	3[4]	x
3	New 2007 Carbureted Outboard[3]	x								x		x	x	3[4]	x
4	Modified with	x	x							x		x	x	1	
5	Modified with	x	x	x						x		x	x	1	
6	Modified with	x	x	x	x					x		x	x	1	
7	Modified with	x	x	x	x	x				x		x	x	1	
8	Modified with	x	x	x	x	x	x			x		x	x	1	
9	Modified with	x	x	x	x	x	x	x		x		x	x	1	
10	Modified with	x	x	x	x	x	x	x		x		x	x	3	x
11	Modified with[2]	x	x	x	x	x	x	x			x	x	x	3	x

[1]Test a minimum of 30 days after the manufacturing date.
[2]Test after fuel system is preconditioned with summer CE10 fuel for 30 days.
[3]Test after fuel system is preconditioned with CaRFG3 fuel for 30 days.
[4]The shaded entries indicate the first day's test results of the 3-day test. The first day data are used for an emission inventory test (see Appendix B, Table 2) and temperature profile tests (see Appendix C, Table 3).

Appendix G

Testing to Determine Design Certification Test Parameters

Table 6

Permeation Evaporative Emission Correlation Testing for Selected Control Hose Exhibits

	X = 15-Day SHED Occupancy		
Fuel	Diurnal (Summer $O_{3)}$	ARB Constant Temp. 105F	U.S. EPA Constant Temp. 23C
CaRFG3 Fuel	x		
U.S. EPA Test Fuel	x	x	x
CE10 Fuel	x	x	x

Preconditioning: Each test exhibit is soaked with the proper test fuel for 140 days.

Table 7

Permeation Evaporative Emission Correlation Testing for Selected Control Fuel Tank Exhibits

	X = 15-Day SHED Occupancy		
Fuel	Diurnal (Summer $O_{3)}$	ARB Constant Temp. 105F	U.S. EPA Constant Temp. 28C
Ethanol Fuel	x		
CE10 Fuel	x	x	x

Preconditioning: Each test exhibit is soaked with the proper test fuel for 140 days.

Appendix G (Continued)

Testing to Determine Design Certification Test Parameters

Vented Emissions for Carbon Canisters

Note from teleconference with Michael Samulski, U.S. EPA

Canisters—U.S. EPA may use a different scale for fuel tanks under 100 gallons and a sliding scale to 400 gallon tanks. 100 gallon tanks may be tested from 78-90 (a difference of 12 degrees) and 400 gallon tanks from 72-96 (a difference of 24 degrees). The reason this is done is to obtain similar emissions losses with the various size tanks. The fuel standard may be RVP9.

	X = 28-Day SHED Occupancy			
Fuel	ARB Diurnal (Summer O_3 Profile) 65-105-65℉	U.S. EPA Diurnal 72-96-72℉	U.S. EPA Diurnal 78-90-78℉	U.S. EPA Diurnal 82-87-82℉
CaRFG3	x			
U.S. EPA RVP9	x			
CE10 Fuel	x	x	x	x

Appendix H

SHED Test Procedure Outline for ARB Outboard Test Boat

Blank Diurnal Test

Blank Test Preconditioning

- Do not wet the boat's fuel system with gasoline
- Begin test a minimum of 30 days after the date of manufacture
- Maintain the boat and engine in the state they were accepted from the dealer

Blank Test Diurnal Procedure

- Move the boat into a variable temperature SHED and soak 6 hours at 65℉
- Begin 65 -105 – 65℉ 24-hour diurnal test.
- Record THC and CH_4 at one minute intervals
- Repeat 24-hour diurnal test twice for a total of 3 24-hour diurnal tests

Appendix I

Inventory and Control Technology SHED Test Procedure Outline for ARB Outboard Test Boat

Hot Soak and Diurnal Tests

Preliminary Steps (Precede the first hot soak and diurnal test with the blank diurnal test)

- After the first wetting with fuel insure the boat and engines are set to manufacturer's specifications
- Fill the fuel tank with test fuel
- Operate the boat according the manufacture's break-in instructions
- Refill the fuel tank to capacity with test fuel
- Operate the boat engine outside at 50% maximum RPM until the boat reaches normal operating temperature and continue operation for another 10 minutes
- Skip this step if it is not applicable. If this is the first test with fuel or the fuel type has changed from the previous test, soak for 30 days at ambient temperature

Preconditioning

- Skip this step if it is not applicable. If this is the first test with fuel or the fuel type has changed from the previous test, soak for 30 days at ambient temperature
- Drain the fuel system
- Fill fuel system to 55% capacity with test fuel.
- Soak for 6-36 hours at 68-86℉

Testing

Hot soak test

- Connect and operate the on-land engine cooling apparatus to the boat
- Operate the boat engine outside at 50% maximum RPM until the boat reaches normal operating temperature and continue operation for another 10 minutes
- Turn off the engine, disconnect the cooling apparatus, roll the boat into the test SHED, and seal the SHED within 2 minutes
- Immediately begin measuring hot soak THC and CH_4 emissions at one minute intervals at 95℉ for 3 hours

Diurnal test

- Place the boat into a variable temperature SHED
- Soak for 6-36 hours with the last 6 hours at 65℉
- Perform 65-105-65ºF 24-hour diurnal SHED test for 72 hours
- Continuously record THC and CH_4 results every minute for the entire profile

Time intervals and temperatures may be re-evaluated after preliminary testing.

Appendix J

Emissions Inventory Hot Soak and Diurnal SHED Test Procedure Outline for In-Use Boats

Preconditioning in-use pleasure craft

- Insure in-use boat is properly broken-in
- Drain the fuel system
- Fill fuel tank to 55% capacity with CaRFG3 summer fuel.
- Operate the boat engine outside at 50% maximum RPM until the boat reaches normal operating temperature and continue operation for another 10 minutes
- Stop the engine
- Soak for 12-36 hours at 68-86℉

Testing

Hot soak test

- Operate the boat engine outside at 50% maximum RPM until the boat reaches normal operating temperature and continue operation for another 10 minutes
- Turn off engine and transport the boat to the test SHED within 2 minutes
- Immediately begin measuring hot soak THC and CH_4 emissions at one minute intervals at 95℉ for 3 hours

Diurnal test

- Place the boat into a variable temperature SHED
- Soak for 6-36 hours with the last 6 hours at 65℉
- Perform 65-105-65ºF 24-hour diurnal SHED test for 72 hours
- Continuously record THC and CH_4 results every minute for the entire profile

Time intervals and temperatures may be re-evaluated after preliminary testing.

Appendix K

Pleasure Craft Real-World Refueling Evaporative Emissions Test Procedure Outline

Preconditioning

- Insure the appropriate type and grade of fuel is available at a roadside or marina gasoline dispensing facility (GDF)
- Install a dummy carbon canister system in the vent line (above the fuel tank level and near the boat's vent port)
- Install a data logger to monitor ambient, fuel tank skin, and waterway (if applicable) temperature
- Drain the fuel tank and refuel to only 10% capacity with the appropriate fuel
- Examine the fuel system vent line for proper operation and determine if later refueling will end with auto shut-off or a predetermined level (prevents a refueling overflow)
- Soak outside for 6 to 36 hours. Data log ambient, fuel tank skin, and waterway temperature for the soak and the refueling test.

Refueling test

- Travel to a roadside GDF or marina
- If the fuel pump is not equipped with a vapor return system seal the nozzle spout in the boat's fill pipe opening
- Weigh and record a purged and capped refueling test carbon canister system and record the weight
- Immediately remove the dummy canister system and install a purged carbon canister system in the fuel tank vent line in its place (keep the caps)
- Begin refueling the boat within 1 minute of installing the test canister at the maximum flow rate with the lowest grade fuel rated for the boat to auto shut-off or to 95% tank capacity.
- Record the time, purchase volume, cost, and gasoline brand and grade
- Remove the carbon canister within one minute of refueling, then recap, reweigh, and record the canister system's weight
- Obtain a fuel sample from the fuel pump for analysis
- Restore the boat's vent line integrity with the dummy canister system

Appendix L

Pleasure Craft Real-World Running Loss Evaporative Emissions Test Procedure Outline

Preconditioning

- Install a dummy carbon canister system in the vent line (above the fuel tank level and near the boat's vent port)
- Install a data logger to monitor ambient, fuel tank skin, and waterway (if applicable) temperature
- Drain the fuel tank and refuel to only 75% capacity with the appropriate fuel
- Examine the fuel system vent line for proper operation and determine if later refueling will end with auto shut-off or a predetermined level (prevents a refueling overflow)
- Soak outside for 6 to 36 hours. Data log ambient, fuel tank skin, and waterway temperature for the soak and refueling test.

Running loss test

- Travel to the waterway
- Between 11 a.m. and 1 p.m. place the boat in the water
- Weigh and record a purged and capped running loss test carbon canister system
- Before starting the boat remove the dummy canister system and install a purged uncapped carbon test canister in the fuel tank vent line (keep the caps)
- Seal any other fuel tank vents (fuel cap)
- Begin the 5-mode engine test cycle (see Appendix M) by starting the engine(s) and idling for 6 minutes 20 seconds
- Complete the 33 minute 20 second test cycle
- Repeat the 5-mode engine test cycle twice for a total of three complete cycles
- Stop the engine(s)
- Remove the carbon canister and recap within one minute after the test cycle
- Weigh and record the recapped test canister system
- Restore the boat's vent line integrity with the dummy canister system

Appendix M

The pleasure craft test cycle for the real-world running loss test was developed using the exhaust emissions marine engine test cycle parameters published in the proposed regulation order California Exhaust Emission Standards and Test Procedures for 2001 Model Year and Later Spark-Ignition Marine Engines, adopted October 21, 1999. The running loss test is performed by starting the boat from a cold start and operating it through 5 different time weighted operating modes from idle to maximum rated RPM and back to idle for a 33 minute 20 second test.

Table 8

Marine Exhaust Test Modes and Time Weighting Factors

Mode Number	1	2	3	4	5
Percentage of Rated RPM	100	80	60	40	Idle
Time Weighting Factor	0.06	0.14	0.15	0.25	0.40

Pleasure Craft Test Cycle for the Real-World Evaporative Emissions Running Loss Test

Table 9

Mode Number	**Percent of Manufacturer's Maximum RPM**	**Length of Time Weighted Running Mode**
1	Idle	6 min 40 sec
2	40%	4 min 10 sec
3	60%	2 min 30 sec
4	80%	2 min 20 sec
5	100%	2 min
4	80%	2 min 20 sec
3	60%	2 min 30 sec
2	40%	4 min 10 sec
1	Idle	6 min 40 sec
	Total Time	33 min 20 sec